EXACT

ELECTRONICS, INC.

CAL. LAB.

INSTRUCTION MANUAL

Type 251 [redacted] 3-67

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INSTRUCTION MANUAL

Type 251

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IF YOUR INSTRUMENT DOES NOT OPERATE

PLEASE

1. Check operating procedure in manual for proper set-up.

2. Check fuse and power supply voltages.

3. Consult the brief trouble shooting guide at the beginning of the MAINTENANCE section of this manual.

4. Call your EXACT representative or the factory collect.

A new instrument should operate properly on arrival and no-one wishes this more than Exact. Many things keep this from happening in every case and if yours is the exception, you should be inconvenienced as little as possible. Some people like to find a trouble themselves, others prefer not to touch an instrument without representation from the manufacturer. **YOUR WARRANTY WILL IN NO WAY BE AFFECTED BY YOUR EFFORT TO FIND THE TROUBLE AND PUT YOUR INSTRUMENT IN EARLY OPERATION.** We leave it to your judgment and offer the services of our representatives and our factory to give you the assistance you need.

All Exact instruments are fully guaranteed against defective materials and workmanship for one year. Replacement parts requests should be clearly identified and the instrument serial number given. The needed parts will be air shipped to you within 24 hours.

EXACT INSTRUMENTS

EXACT ELECTRONICS PRODUCES THREE TYPES OF INSTRUMENTS: WAVEFORM SYNTHESIZERS, FUNCTION GENERATORS, AND VOLTAGE CALIBRATORS. ALL OF THE EXACT PRODUCTS ARE PRECISION INSTRUMENTS, BUILT TO HIGH STANDARDS UTILIZING QUALITY COMPONENTS. EXACT'S INSTRUMENTS ARE USER-ORIENTED AND CONTAIN FEATURES WHICH PROVIDE APPLICATION VERSATILITY.

WAVEFORM SYNTHESIZERS ARE A NEW APPROACH TO GENERATION OF COMPLEX WAVEFORMS. WAVEFORMS WITH PERIODS OF 2 MICRO-SECONDS TO 50 SECONDS CAN BE GENERATED. INFINITE COMBINATIONS OF SLOPES, AMPLITUDES AND WIDTHS CAN BE PROGRAMMED. WAVEFORMS REQUIRED IN TELEMETRY, ANALOG- AND DIGITAL-COMPUTORS, DISTORTION STUDIES AND MANY OTHER FIELDS CAN EASILY BE SIMULATED. WAVEFORM SYNTHESIZERS ARE ALSO SUITED FOR DIVERSE APPLICATIONS IN MEDICAL INSTRUMENTATION WHERE NERVE AND MUSCLE-POTENTIALS MUST BE SIMULATED. WAVEFORM SYNTHESIZERS CAN SOLVE MANY COMPLEX WAVEFORM PROBLEMS WHICH PREVIOUSLY REQUIRED COSTLY AND IMPRACTICAL CUSTOM-BUILT GENERATORS OR RECORDING/REPRODUCING EQUIPMENT.

FUNCTION GENERATORS ARE NOT NEW TO THE ELECTRONICS INDUSTRY, BUT EXACT'S FUNCTION GENERATORS HAVE SEVERAL VALUABLE FEATURES WORTHY OF CAREFUL CONSIDERATION. EXACT'S FUNCTION GENERATORS NOT ONLY PROVIDE A CHOICE OF OUTPUT WAVEFORMS, BUT ALSO PROVIDE AUXILIARY OUTPUTS OF ALL AVAILABLE WAVEFORMS SIMULTANEOUSLY. EXTENDED FREQUENCY-RANGE (0.001 TO 10,000 CPS) EXPANDS APPLICATIONS TO REQUIREMENTS FOR VERY-SLOW WAVEFORMS. TRIGGERED OPERATION SIMPLIFIES INTEGRATING THE FUNCTION GENERATOR WITH OTHER EQUIPMENT, AND ALLOWS OBTAINING AN OUTPUT BEGINNING AT ANY DESIRED POINT ON THE WAVEFORM.

VOLTAGE CALIBRATORS ARE DESIGNED TO BE USED IN THE LABORATORY, IN THE FIELD, OR ON PRODUCTION LINES. THEY ARE IDEALLY SUITED FOR CALIBRATION OF TEST OR OPERATIONAL EQUIPMENT. ACCUMULATED TOLERANCES CAN BE CONTROLLED BY UTILIZING EXACT'S VOLTAGE CALIBRATORS. THE CALIBRATORS PRODUCE AN OUTPUT VOLTAGE, EITHER OF DC LEVEL OR SQUARE WAVEFORM, WITH ¾% ACCURACY. THE VOLTAGE CALIBRATORS' COMPACTNESS AND LIGHT WEIGHT ENSURES HAND-CARRYING MOBILITY IN THE LABORATORY OR FIELD.

EXACT ELECTRONICS, Inc.

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ALL PORTIONS OF THIS MANUAL APPLY EQUALLY TO THE TYPES 250 AND 251 UNLESS SPECIALLY NOTED AS APPLYING TO THE TYPE 251 ONLY.

SPECIFICATIONS—TYPES 240, 250 AND 251

MAIN OUTPUT:

AMPLITUDE	5 to 25 volts P-P
IMPEDANCE	200 ohms (cathode follower)
CURRENT	-3 to +15 ma max
AMPLITUDE STABILITY	0.5% of output amplitude
AMPLITUDE CHANGE WITH FREQUENCY	0.5% @ .001 to 1000 cps 2.0% @ 1000 to 10000 cps (4%, on triangle only)
FREQUENCY RANGE	.001 to 10,000 cps
DIAL INDICATION ERROR	+3%
LONG-TERM FREQUENCY STABILITY	+2%
DC REFERENCE LEVEL RANGE	-13 to +13 volts or switched to ground
DC REFERENCE LEVEL STABILITY	less than 50 MV (except cosine)
DC REFERENCE LEVEL POSITION—Center of sine and triangle waveforms; base of square ramp and cosine waveforms	

AUXILIARY OUTPUTS: (250/251 only)

AMPLITUDE	35 volts P-P (fixed)
IMPEDANCE	2000 ohms (unbalanced)
CURRENT	5 ma max
AMPLITUDE STABILITY AND CHANGE WITH FREQUENCY	(same as main output)
DC REFERENCE LEVEL	0 volts (fixed)
FREQUENCY RANGE	(Same as main output)
WAVEFORMS AVAILABLE (SIMULTANEOUS)—Sinewave, squarewave, triangle, ramp and cosine (251 only)	

TRIGGER OUTPUT:

DIFFERENTIATED SQUARE WAVE

AMPLITUDE	100 volts P-P minimum
FREQUENCY	Same as output frequency

TRIGGER INPUT: (250/251 ONLY)

AMPLITUDE	10 volts P-P minimum
RISETIME (POSITIVE GOING)	2 usecs or faster
DELAY BETWEEN PEAK TRIGGER PULSE AND START OF OUTPUT	1 usec max

WAVEFORM CHARACTERISTICS:

Squarewave

RISETIME	5 usecs or faster
SYMMETRY	99%
OVERSHOOT	1% max
DROOP	1% max

Triangle

LINEARITY	99.5%
SYMMETRY	99%

Sinewave

TOTAL DISTORTION	less than 2%

Ramp

LINEARITY	99.5%
FALL TIME	6% of period (max)

Cosine

TOTAL DISTORTION	2% max

POWER REQUIREMENTS	105 to 125/210 to 230 vac—50-400 cps—125 watts (240)—175 watts (250/251)
WEIGHT	Gross 22 lbs—Net 16 lbs
VOLUME	2 cu. ft.
PRICES* (FOB FACTORY)	Type 240 $450.00 Type 250 $550.00 Type 251 $625.00

*Type 240RM, 250RM and 251RM (rack mount models) are available at no additional cost
*Complete with 2 output cables (42") and 2 instruction manuals

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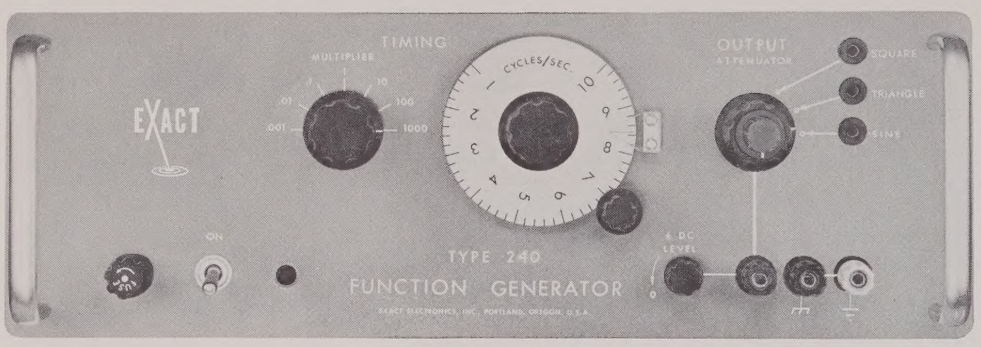
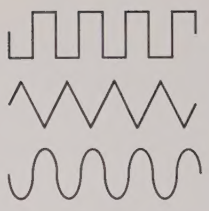
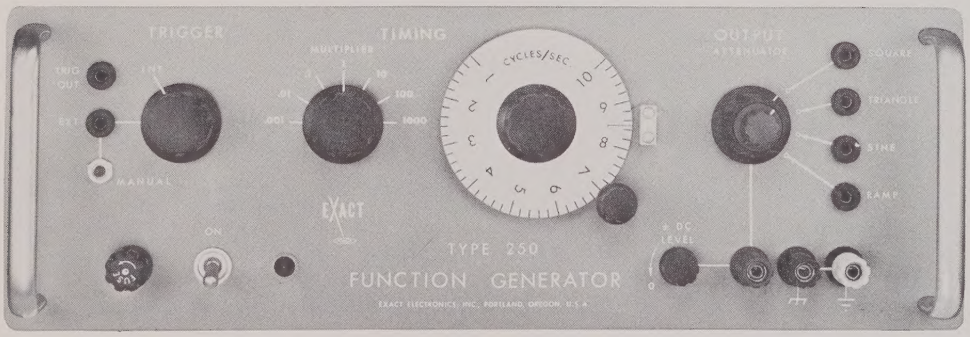
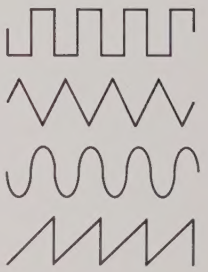


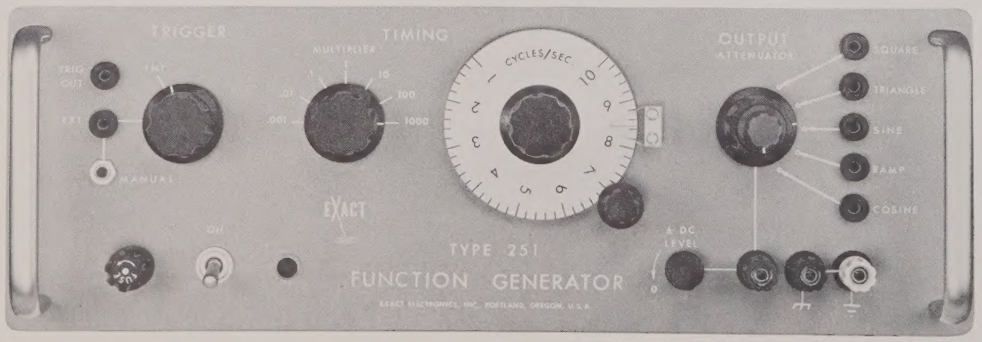


NOW THERE ARE THREE.....





'EXACT' FUNCTION GENERATORS



1-3 OPERATION

1-31 The general purpose of the Type 250 is to generate square, sine, triangle and ramp waves over a continuously variable frequency range of 0.001 cycles per second to 10 KC. These waveforms are available simultaneously from the designated jacks on the right hand side of the front panel or singly as selected from the main output jack. The waveforms may be continuous, externally triggered or triggered by the Manual push button.

1-32 For first time operation, follow this procedure:

*BE SURE UNIT HAS GOOD VENTILATION. DO NOT STACK BOOKS OR PAPERS ON TOP OF CABINET.

A. Turn power switch ON.

B. Set the OUTPUT switch to TRIANGLE.

C. Turn the OUTPUT ATTEN. (red concentric knob) fully CW.

D. Turn the ± DC LEVEL control all the way CCW until you are in the switched position.

E. Set the CYCLES/SECOND dial to 5.

F. Set the TIME MULTIPLIER to 100.

G. Set the TRIGGER switch to INT (off).

H. Connect the MAIN OUTPUT to a monitor scope.

I. Be sure that the CHASSIS ground post and the CABINET Ground post are shorted together.

J. Connect the TRIGGER OUT jack to the external trigger input of the monitor scope.

K. Set the monitor scope controls for:

External triggering
2 msec/cm time base
DC coupled input
5 volts/cm vertical deflection

1-33 You should be observing about 10 cycles of triangle waveform on the monitor scope. Try the following adjustments to become better acquainted with the front panel controls

A. Switch the OUTPUT switch to each of the 4 waveforms and notice the stability of amplitude and DC level.

B. Turn the OUTPUT ATTEN. CCW (you should attenuate from 30 to approx. 5 volts).

1-33

C. Connect your main output lead from the scope to each of the four separate SQUARE, TRIANGLE, SINE AND RAMP waveforms. These amplitudes are fixed at approximately 30 volts and their center DC reference levels are fixed at 0. (internal adjustments can change this level if desired).

D. Again observe the MAIN OUTPUT with the monitor scope and turn the $\pm$DC LEVEL adjust CW through its full range. The waveform should move from entirely below ground to entirely above ground.

E. Vary the CYCLES/SECOND and the TIME MULTIPLIER and observe the amplitude and DC level stability.

F. Turn the TRIGGER OUT switch to EXT (in) and spply a 10 volt trigger signal with better than a 2 usec rise-time. Also press the MANUAL trigger button. You will notice that the waveforms trigger at the following levels:

Square	most negative
Sine	center
Triangle	center
Ramp	most negative
Cosine	most negative (90° after Sine)

You now have your "PILOT'S LICENSE" and we hope you will enjoy the use of your FUNCTION GENERATOR. Should you have any trouble or want to do something special with the unit (everyone does), please call your local representative listed at the front of this manual or phone us collect.

**********TYPE 251 ONLY**********

1-34 MANUAL TRIGGERING OF COSINE

The COSINE just <u>does not</u> like to be manually triggered. If you must use it in this operating mode:

Set the CYCLES/SEC dial to 10 and RANGE switch to 100. Monitor the COSINE out and set your test scope so that it triggers from the start of the waveform (most negative point). Observe the DC level of the most negative point on the COSINE. Turn the TRIGGER switch on the 251 to EXT and adjust HOLDOFF DC LEVEL (R136) while pressing the MANUAL trigger until the COSINE starts at a point slightly more negative than the most negative point observed in the free running mode. This level should be rechecked whenever you change frequency.

1-4 TROUBLE TIPS

FUSE BLOWING ----------	Shorted rectifier diodes.
EXCESSIVE HUM, DRIFT OR JITTER -------	Power supplies out of regulation. *Ground strap between chassis ground and circuit ground missing on front panel.*
NO OUTPUT OR IMPROPER DC LEVEL OUT ----------	Trigger source in EXT position. Check DC level pot/switch.
TIMING OFF DISTORTED TRIANGLE ----	Bad V4 or V5. Miller DC Bal (R166) adjustment off.
RAMP INOPERATIVE OR SKIPPING ----------	Bad V10. Ramp length/level adjustments off.
SQUARE WAVE UNSYMMETRICAL ---------	Square symmetry (2) adjustments off.
DISTORTED SINE WAVE -----	Be sure to accurately check timing of unit first. Slightly readjust "A" sine shape R171. Check square wave symmetry. Check triangle linearity and adjustment of R166, MILLER DC BALANCE. Only if the above does not help should you change V7 and readjust sine shaping pots.
MANUAL OR EXTERNAL TRIGGERING INOPERATIVE OR UNIT STILL RUNS CONTINUOUSLY IN EXT POSITION ----------	Bad V3. Open Diode D102. Readjust, R136.
COSINE DISTORTED --------	Readjust COSINE X1 BAL (R237) and COSINE X10 BAL (R182). Check adjustment of COSINE COMP (R243) at 10KC. Check sine distortion. Change V6 and re-balance.

1-5 APPLICATIONS

General waveform source for research, analog computers, systems checking.

Check out of recorders (Ramp - Triangle).

SOURCE OF SWEEP VOLTAGES FOR MONITOR SCOPES, RECORDERS, ETC. (RAMP).

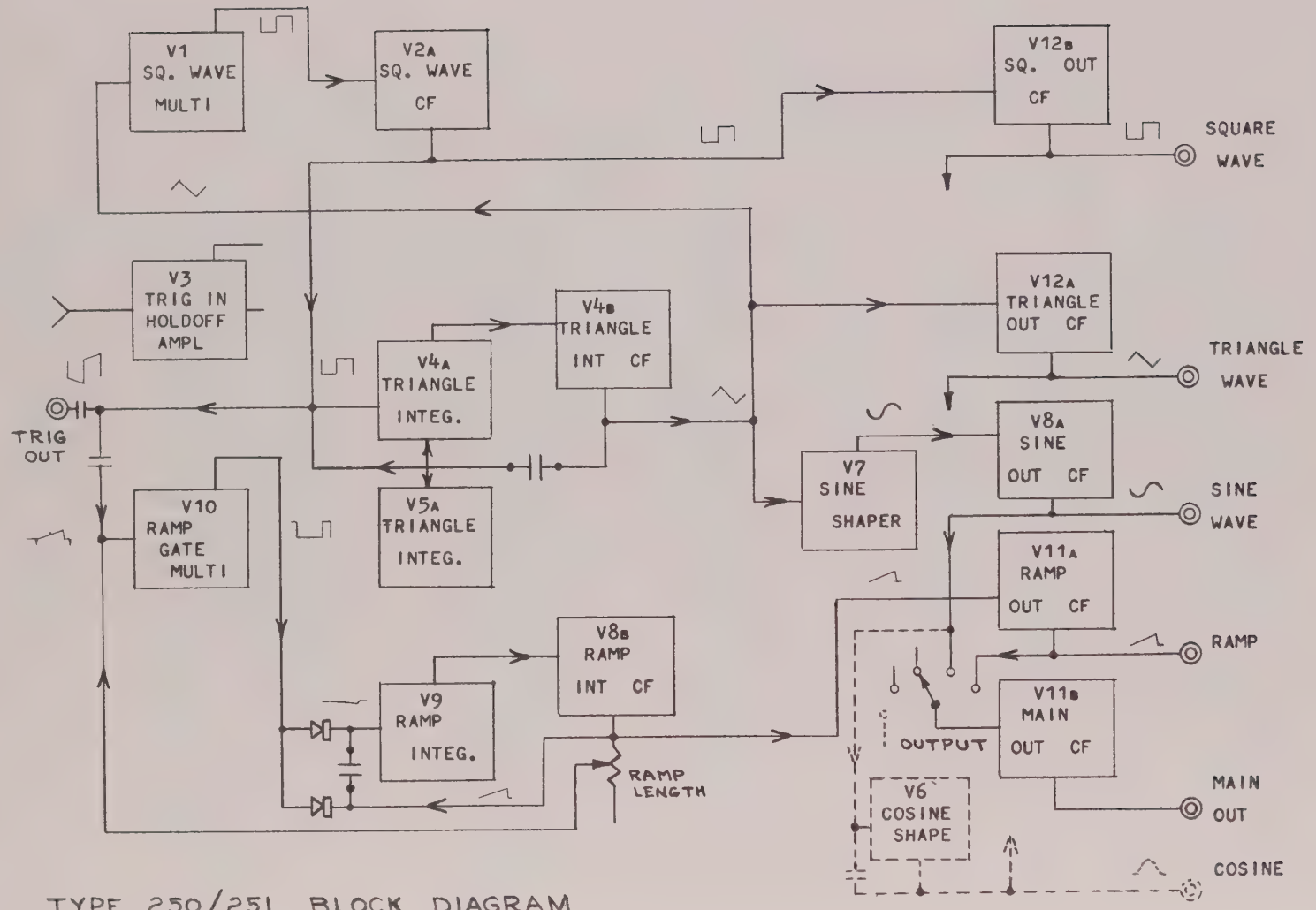
LOW FREQUENCY SQUARE WAVE RESPONSE CHECK.

TRIANGLE AS RASTER GENERATOR.

LINEARITY CHECKING OF INSTRUMENTS OR SYSTEMS BY VARYING DC LEVEL AMPLITUDE OR FREQUENCY WHILE HOLDING ONE OR BOTH OF THE OTHER PARAMETERS CONSTANT.

DELAY TRIGGER GENERATOR (TRIGGER TYPE 250 EXTERNALLY AND USE SQUARE OR RAMP FALL, WHICH IS VARIABLE OVER ENTIRE TIMING RANGE) TO TRIGGER SCOPE OR OTHER EQUIPMENT.

SERVO SYSTEM CHECKING (SINE-COSINE).



TYPE 250/251 BLOCK DIAGRAM

2-2 TROUBLE SHOOTING PROCEDURE

2-21 POWER SUPPLY

All circuits depend on the regulated -210V, +100V & +250V. The more critical generating circuits also depend on the -11V filament regulation. Always check these supplies for proper voltage and below 10mv of ripple. (500mv on -11V supply.)

-210V problems check V103; V102; V101; -210 ADJ R23; Diodes D9-D12.

+100V problems check -210V; V104; V103; divider voltage pin 1, V104; diodes D5-D8.

+250V problems check -210V; V106; V105; divider voltage pin 1, V106; diodes D1-D4.

-11V problems check Q1; ZENER, D17; diode D18, diodes D13-D16.

2-22 SQUARE WAVE

V1 generates the square wave and also gates the triangle miller integrators V4 & V5. Problems involving square wave only should be traced to V12B, V2A and V1 in that order.

2-23 TRIANGLE

V4 & V5 are differential miller integrators and produce a positive and negative going voltage which is fed back to V1 to determine the flipping time of the multivibrator. Problems involving triangle only should be traced to V12A, V4, V5, R166 & R105 settings in that order.

2-24 SINE

V7 shapes the triangle and depends on accurate symmetry of the square wave and triangle as well as proper input level of triangle. All previous settings and calibration procedures should be checked before further trouble shooting the sine wave. After doing this, trace problem to V8A, V7, SINE SHAPE adjustments (R171, R172, R173) and SINE DC LEVEL R182 in that order.

2-25 RAMP

V10 is triggered by V1 (internal triggering) or V3 (external triggering) and furnishes the gate for miller integrator V9. Problems involving ramp only should be traced to V11A, V9, V8B, V10, RAMP LEVEL & RAMP LENGTH (R209 & R211) settings, D108 & D109 in that order.

2-26 MULTIPLE TROUBLES

Square Wave Symmetry Adjustments would cause malfunction of triangle and sine.

Switch contact problems could cause assorted malfunctions.

External trigger tube V3, holdoff level R136 and diode D104 could all cause lack of or improper external triggering.

Lack of main output could be V11B or the switch pot ±DC OUTPUT LEVEL.

2-3 CIRCUIT DESCRIPTION

2-31 POWER SUPPLY

The three power supplies are all based on the same principle; a DC amplifier is referenced to a standard voltage (a 5651 gas tube or precision dividers from -210V). Any variation from line or load is amplified by the DC amplifier and passed along as a control voltage to the series regulator tube. The filament supply is regulated by a transistor referenced to a zener diode.

2-32 SQUARE WAVE GENERATOR

V1 is a cathode coupled multivibrator. Its output (pin #6) swings from below -100V, when V1B is conducting, to +100V when it is cut off. The time duration of each half-cycle is determined by the triangle waveform at grid pin #9. The triangle from V4A is coupled back to the grid pin #9 of V1A. The triangle now determines the switching of the multivibrator V1. The triangle must always pass through the same DC levels to switch V1 and therefore this partly determines the timing of the instrument.

The Loop Gain of the cathode coupled multivibrator is determined by its cathode current. This determines the final timing and is controlled by R105.

V2A is a cathode follower whose putput has four parts.

a) SQUARE WAVE SYMMETRY (X10), R122 provides for equal voltage but opposite polarity at X10 end of VARIABLE (CPS) dial for each half-cycle of V1.

b) Provides standard SQUARE WAVE to output cathode follower V12B.

c) Provides square wave to Miller Integrator timing resistors and capacitors (R132-R135 and C102A-F).

d) Provides square wave to ramp gate V10 and "turn-off" voltage to external trigger multivibrator, V3.

2-33 TRIANGLE GENERATOR

V4A, V4B & V5A are push-pull Miller Integration amplifiers with an associated cathode follower. The symmetrical square wave from V2A is fed to grid pin #2 of V4A and the integrator action produces a triangle waveform at the cathode follower cathode (pin #8 of V4B). Time constants for the integrator are C102 (A-F), R124A and R132-R135. MILLER DC BAL (R166) determines the voltage level fed back to the grid of V1A and thus the DC level amplitude to V1.

2-34 SINE WAVE GENERATOR

V7 is a pentode whose bias characteristics are adjusted by three sine shaping adjustments, R171, R172 and R173. The linear triangle from V4B is shaped by these adjustments to produce a very low distortion sine wave at the plate pin #5.

SINE ADJ A controls the DC level of the grid.

SINE ADJ B controls the amplitude of the triangle into grid pin #1 of V7.

SINE ADJ C controls the suppressor bias of V7.

2-35 RAMP GENERATOR

V10 IS A CATHODE COUPLED MULTIVIBRATOR WHICH SHAPES THE RELATIVELY SLOW RISE SQUARE WAVE INPUT TO A FAST RISE GATE TO START THE MILLER INTEGRATOR V9. RUN-UP ACTION IS STARTED BY THE GATING PULSE FROM V10B. TIMING CONSTANTS ARE R124B, R203-R207 AND C115A-F. D108 AND D109 RETURN THE TIMING CAPACITOR TO THE PROPER QUIESCENT OPERATING LEVEL AFTER RUN-UP.

V8B FURNISHES THE NECESSARY PLATE TO GRID FEED BACK FOR THE INTEGRATOR AND IS ALSO THE CATHODE FOLLOWER TAKE OFF TO THE OUTPUT AMPLIFIER.

RAMP LENGTH (R211) DETERMINES THE NECESSARY VOLTAGE LEVEL TO RESET GATING MULTI V10 WHICH IN TURN STOPS THE RUN-UP AND TERMINATES THE RAMP.

2-36 MAIN OUTPUT

V11B IS A CONVENTIONAL CATHODE FOLLOWER. THE PROPER WAVEFORM BEING FED TO THE GRID IS SELECTED BY THE OUTPUT SWITCH, SW104. THE DC LEVEL OF THE CONTROL GRID IS DETERMINED BY:

A) R216, R217 IF ±DC OUTPUT LEVEL SWITCH IS CCW IN SWITCHED POSITION.

B) R214 IF ±DC OUTPUT LEVEL SWITCH IS CW FROM SWITCHED POSITION.

2-37 EXTERNAL TRIGGER

V3 IS A BI-STABLE MULTIVIBRATOR WHOSE OUTPUTS ARE USED TO:

A) CLAMP THE TRIANGLE GENERATOR GRID (PIN #2, V4A) NEAR GROUND LEVEL WHICH STOPS OPERATION OF THE GENERATING CIRCUITS V1, V2, V4 AND V5.

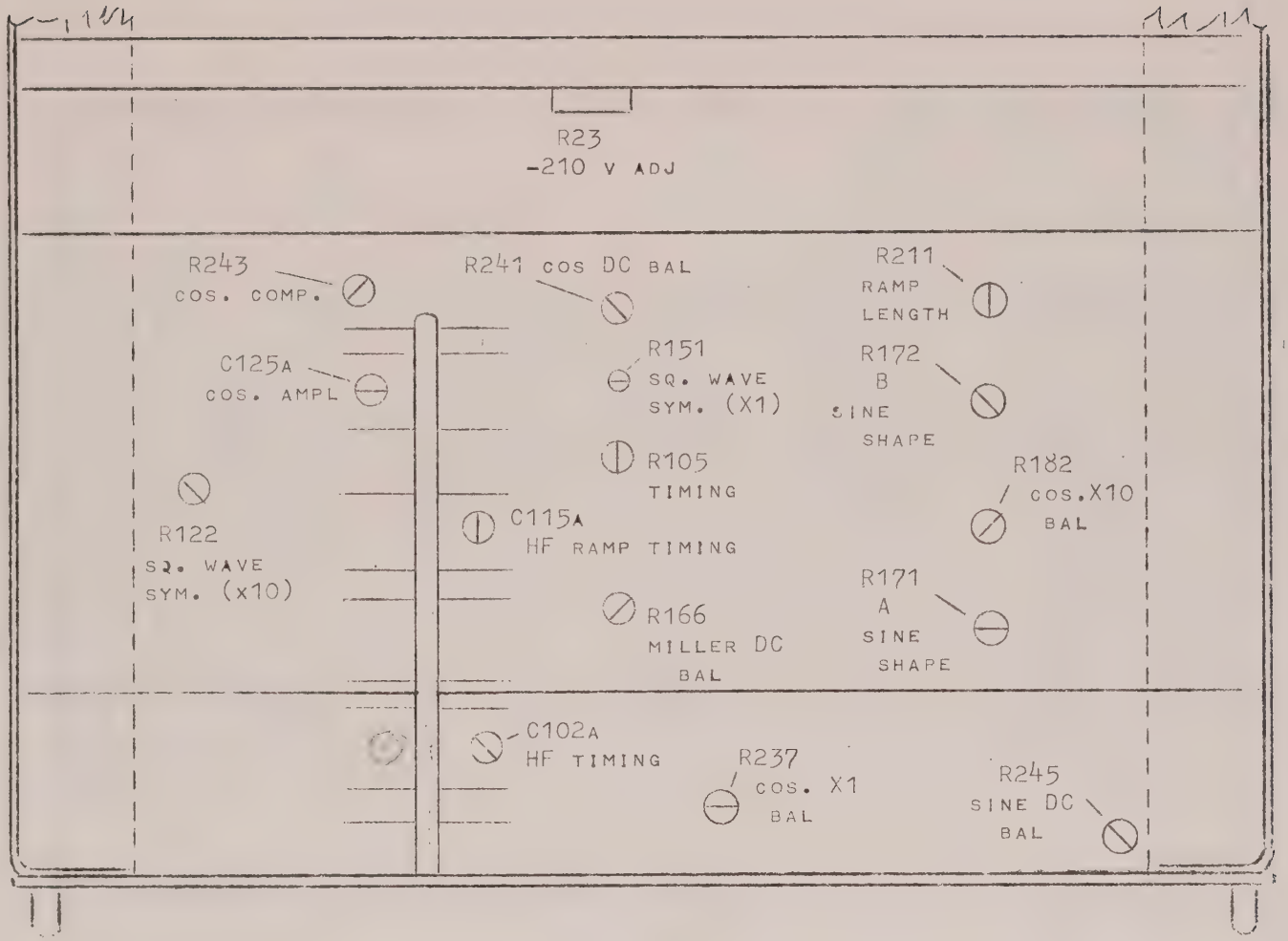
B) PROVIDE A TRIGGER OUT PULSE AND A GATE TO V10A IN EXT TRIGGER OPERATION.

When the TRIGGER switch is in EXT position, the first negative going portion of the square at pin #7 of V3 will turn off that side of the tube. This will stop all internal triggering due to the clamp action at grid pin #2 of V4A. The negative going portion of an external or manual trigger at pin #2 of V3A will cause that half of the tube to cut off -- V3B will conduct and the clamp will be removed. Operation will contiue for one cycle until the falling edge of the square wave again "locks out" V3.

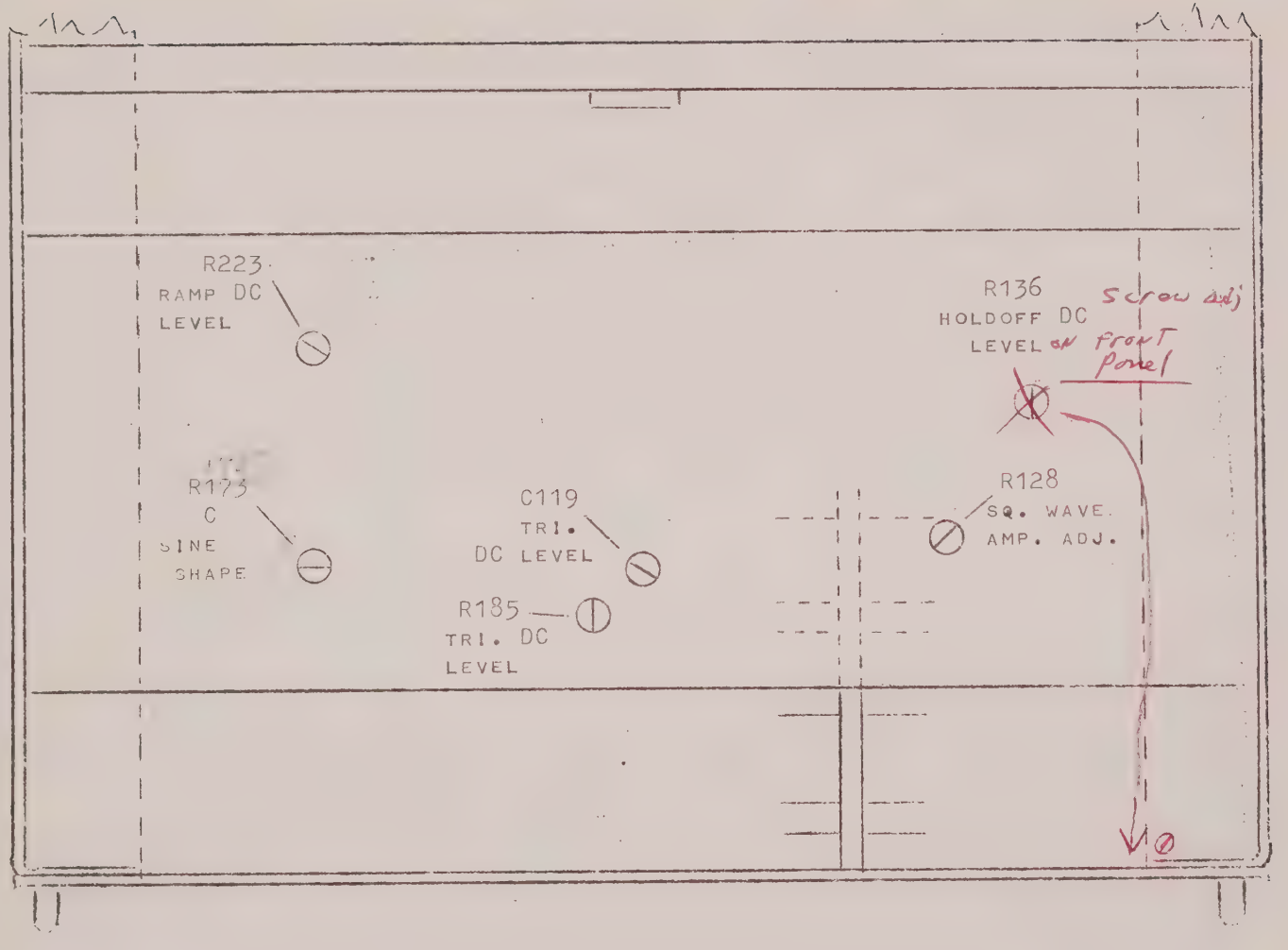
**********TYPE 251 ONLY**********

2-38 COSINE GENERATOR

The cosine waveform is obtained from integrating the sine wave. The integrator amplifier is V6. SW103G, H, & I will place the proper time constants in the miller integrator. R124C reduces the amplitude of the sine wave input when the variable multiplier dial is rotated. When the variable time is increased from 1 to 10, the amplitude of the input sine wave is increased by a ratio of 1 to 10. This will give a nearly constant output cosine wave. V6B is the cosine cathode follower output.



TYPE 251 CALIBRATION ADJUSTMENTS TOP VIEW



TYPE 251 CALIBRATION ADJUSTMENTS BOTTOM VIEW

SECTION III CALIBRATION PROCEDURE

The following pieces of test equipment are recommended to give the Type 250 FUNCTION GENERATOR a complete calibration.

1. 20,000 ohm/volt voltmeter.
2. 100KC bandpass oscilloscope with DC coupled input and external triggering capabilities.
3. Variable line voltage input device such as a VARIAC.
4. Distortion analyzer or waveform analyzer such as DONNER or HEWLETT PACKARD manufacture.

3-1 POWER SUPPLY

TYPE 250

Strap between chassis gnd & circuit gnd
TRIGGER SOURCE -- EXT

3-11 MEASURE SUPPLY RESISTANCES TO GROUND

-210 volt -- approx. 5.5Kohms
+95 volt -- approx. 19Kohms
+250 volt -- approx. 60Kohms

TYPE 250

Plug AC input into VARIAC set to 117V
Power switch -- ON
TRIGGER SOURCE -- EXT

3-12 CHECK VOLTAGES

-210 volts -- adjust R23
+95 volts -- 5%
+250 volts -- 5%
- 11 volts (reg. filaments) -- 10%

TEST SCOPE

Vertical sens -- most sens position
Input coupling -- AC
Timing -- 10msec/cm
Trigger -- [illegible]

3-13 CHECK RIPPLE AND REGULATION

Put test scope input lead on each of the power supplies while varying the line voltage from 105V to 125V. Ripple should be no greater than listed below throughout the input voltage range:

-210 volts -- 10mv
+100 volts -- 10mv
+250 volts -- 10mv
- 11 volts -- 500mv

3-2 TRIANGLE, SQUARE AND TIMING

TYPE 250
TRIGGER SOURCE -- INTERNAL
RANGE switch -- 100
Check VAR for mech center & set to 10
OUTPUT ATTEN -- full CW

TEST SCOPE
TRIGGERING -- INTERNAL
SWEEP TIME -- 1msec/cm
VERTICAL SENS -- 50V/cm .1/cm X10
INPUT coupling -- DC

3-21 TRIANGLE BALANCE

Put scope probe on pin #2 of V4 and adjust MILLER DC BAL (R166) through range until stable, linear triangles appear on scope.

This adjustment will provide a triangle with good linearity. Timing at this point may not be correct, but following adjustments will give proper calibration.

INSTRUMENT SHOULD HAVE BEEN ON AT LEAST 15 MINUTES BEFORE ANY OF THE FOLLOWING ADJUSTMENTS ARE MADE:

3-22 TIMING (PRELIMINARY)

Put scope probe in triangle output and check for 10 triangles for 10cm on scope. Time by adjusting TIMING ADJ (R105).

TYPE 250

TRIGGER SOURCE -- INTERNAL
RANGE switch -- 100
VARIABLE -- 10

TEST SCOPE

TRIGGERING -- INTERNAL
SWEEP TIME -- 100 usec/cm
VERTICAL SENS -- 10V/cm
INPUT coupling -- AC

3-23 SQUARE WAVE SYMMETRY

Connect test scope to SQUARE output of Type 250 and adjust scope triggering so that a change between plus and minus INTERNAL will cause a stationary polarity reversal of one cycle of the square wave.

Position the rise or fall to the center of the graticule and turn the scope magnifier ON. While switching the scope trigger between plus and minus INTERNAL triggering adjust SQUARE W. SYMMETRY (X10) R122 for no shift (equal positive and negative portions).

TYPE 250

Change VARIABLE to 1

TEST SCOPE

Change SWEEP TIME to 1msec/cm

Repeat the preceding calibration adjusting SQUARE W. SYMMETRY (X1) R151.

These two adjustments interact, so careful checking back and forth is necessary if either is adjusted more than a noticeable amount.

TYPE 250

TRIGGER SOURCE -- INTERNAL
RANGE SWITCH -- 100
VARIABLE -- 10

TEST SCOPE

TRIGGERING -- EXTERNAL from SQUARE out
SWEEP TIME -- 1msec/cm
VERTICAL SENS -- 10V/cm
INPUT coupling -- AC

3-24 TIMING (FINAL)

With test scope on TRIANGLE OUTPUT and triggering scope from SQUARE output of Type 250 recheck TIMING (R105).

TYPE 250

Change VARIABLE to 1

TEST SCOPE

Change SWEEP TIME to 10msec/cm

Observe amount of error at this end of dial. Loosen set screw on dial knob and mechanically shift to compensate for error. DO NOT tighten screw until X10 end of dial has been rechecked.. R124A is very sensitive at X1 end, so be very careful.

TYPE 250

VARIABLE -- 1
Change RANGE to 1000

TEST SCOPE

Change SWEEP TIME to 100usec/cm

Adjust timing capacitor C102A for 1 cycle in 10cm.

Change variable to X10 and adjust C119 (H.F. TRI. COMP) for 10 cycles. Check variable at X1 and readjust C102A if necessary. Repeat adjust until X1 and X10 are tracking.

Check timing on all but the slowest two ranges by observing 10 cycles for 10cm.

TYPE 250

Change RANGE to .01

TEST SCOPE

SWEEP TIMING to 1sec/cm

Check timing by observing one cycle for 10cm

TYPE 250
Change RANGE to 10

TEST SCOPE
SWEEP TIME (decade) -- 1msec/cm
Calibrate the SWEEP TIME MULTIPLIER or VERNIER so that it gives a sweep 10 times slower than the decade step indicated on the scope.

TYPE 250
Change RANGE to .001

TEST SCOPE
Change SWEEP TIME (decade) to 1sec/cm
10sec/cm with vernier

Check for one cycle per 10cm
(Have patience!)

TYPE 250
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
OUTPUT ATTEN -- full CW

TEST SCOPE
TRIGGERING -- EXT from SQUARE out
SWEEP TIME -- 1msec/cm
VERTICAL SENS -- approx 10V/cm
INPUT coupling -- DC

3-25 TRIANGLE LEVEL & SQUARE WAVE AMPLITUDE

With test scope on SQUARE output adjust the vertical positioning and vertical gain of the test scope to present exactly 4cm of square wave with DC ground at the center (plus and minus 2cm of signal around ground).

With test scope monitoring TRIANGLE output and without touching any scope controls, adjust TRIANGLE DC level, R185, until the center DC level of the triangle wave matches the center DC level of the square wave.

Observe the amplitude of the triangle

With test scope monitoring SQUARE output, adjust SQUARE WAVE AMPLITUDE, R128, until the square wave is the same amplitude as the triangle.

3-3 TRIGGERING (LOCKOUT)

TYPE 250

TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
OUTPUT ATTEN -- full CW

TEST SCOPE

TRIGGERING -- EXT from SQUARE out
SWEEP TIME -- 1msec/cm
VERTICAL SENS -- 10V/cm
INPUT coupling -- DC

With test scope on TRIANGLE output center the triangle waveform on the scope (DC ground -- center graticule = waveform center)

TYPE 250

Change TRIGGER SOURCE to EXTERNAL

TEST SCOPE

Change sweep to free run

With test scope on TRIANGLE output observe the DC shift of the trace as the VARIABLE dial on the 250 is rotated from 10 to 1. Adjust HOLDOFF DC LEVEL, R136, so that the shift is balanced about the center of the graticule.

TEST SCOPE

Change TRIGGERING to EXT

20V

CONNECT THE TRIGGER OUT OF THE TYPE 250 TO THE EXTERNAL TRIGGER INPUT OF THE SCOPE. APPLY A 10V SIGNAL FROM THE SCOPE CALIBRATOR TO THE EXT INPUT OF THE TYPE 250. ADJUST THE TEST SCOPE FOR TRIGGERED OPERATION AND CHECK FOR PROPER TRIGGERING AND OUTPUT WAVEFORM FROM THE TYPE 250. REMOVE THE CALIBRATOR SIGNAL FROM THE TYPE 250 AND PRESS THE MANUAL BUTTON. YOU SHOULD OBSERVE ONE CYCLE OF THE WAVEFORM EACH TIME YOU PRESS THE BUTTON.

*****TYPE 251 ONLY FOLLOW PROCEDURE 1-34 UNDER OPERATION ****

3-4 TRIANGLE LINEARITY

IN THIS CHECK IT IS VERY IMPORTANT TO USE A SCOPE WHOSE CRT GEOMETRY AND LINEARITY ARE CALIBRATED TO 1/2% OR BETTER. (CHECK SCOPE LINEARITY BY LOOKING AT SCOPE'S SAWTOOTH OUT.)

TYPE 250
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
OUTPUT ATTEN -- FULL CW

TEST SCOPE
TRIGGERING -- +INTERNAL
SWEEP TIME -- 50USEC/CM
VERTICAL SENS -- APPROX 10V/CM
INPUT COUPLING -- DC

WITH THE TEST SCOPE ON TRIANGLE OUTPUT SET THE SCOPE VERTICAL GAIN AND SWEEP VERNIER TO JUST DISPLAY THE RISING HALF CYCLE OF THE TRIANGLE OVER THE ENTIRE GRATICULE AREA. OBSERVE LINEARITY.

TEST SCOPE
CHANGE TRIGGERING TO - INTERNAL

OBSERVE LINEARITY WITH JUST THE FALLING HALF CYCLE OF THE TRIANGLE OCCUPYING THE FULL GRATICULE AREA OF THE TEST SCOPE.

TYPE 250
CHANGE VARIABLE TO 1

TEST SCOPE
CHANGE SWEEP TIME TO 500USEC/CM

Repeat the preceding check at the X1 end of the 250 VARIABLE dial.

If the nonlinearity is approaching 1%, try changing V4 and V5 and go through calibration steps 3-21, 22, 23 & 24.

Almost all the adjustments up to this point affect the shape of the sine wave. The pureness of the sine wave will depend on the accuracy of your previous calibration. Any subsequent changes or recalibration of previous steps will make it necessary for you to recheck the calibration of the sine wave.

3-5 SINE WAVE CALIBRATION (see photo 3-52)

Adjustment of the sine wave, if it is quite far out of tolerance, is as much an art as it is a science and you are asked to exercise tolerance and patience. (Checking with the photos of poorly adjusted sine waves will keep you from going too far astray.)

TYPE 250
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
OUTPUT ATTEN -- full CW

TEST SCOPE
TRIGGERING -- EXT from TRIGGER OUT
SWEEP TIME -- 200 to 500 usec/cm
VERTICAL SENS -- approx. 10V/cm
INPUT coupling -- DC

3-51 PRELIMINARY SETTINGS

With the test scope on the SINE output, adjust the scope triggering for stable EXT triggering from the TRIGGER OUT of the Type 250.

Adjust C SINE SHAPE, R175 CCW to ground.

Adjust A SINE SHAPE, R171 and B SINE SHAPE, R172 for the best looking sine possible. These adjustments are very interdependent and one can be at a setting where it is impossible for the other to correct. B SINE SHAPE controls more of the amplitude and A SINE SHAPE more of the shape itself. It is best to set B for nearly maximum amplitude, then as A is adjusted B can be reduced in amplitude to maintain proper shape. This is an optimum wave shape at this point.

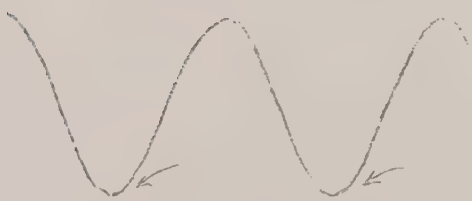
Now adjust C SINE SHAPE, R175, to round the bottom of the sine. A and B can be readjusted for final smoothing.

3-52

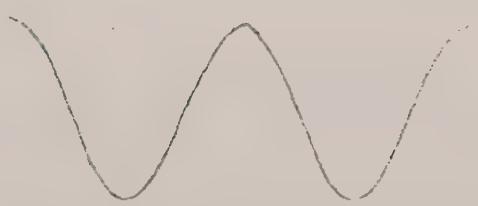
SINE ADJ B ABOUT CORRECT BUT SINE ADJ A TOO FAR CW. ROTATE "A" CCW UNTIL BOTTOM IS LESS FLAT AND TOP MORE FULL AND ROUND.

SINE ADJ B TOO FAR CCW. ROTATE CW UNTIL TOP IS PROPER SHAPE. IF BOTH TOP AND BOTTOM ARE FLAT, REDUCE AMPLITUDE WITH SINE ADJ B (CW ROTATION) AND ADJUST "A" TO RE-CENTER WAVEFORM (SYMMETRICAL SHAPE).

NOT ENOUGH ADJUSTMENT OF EITHER "A" OR "B". INCREASE AMPLITUDE (CW) WITH SINE ADJ B AND ADJUST "A" CW TO RE-CENTER WAVEFORM.



APPROXIMATELY OPTIMUM SETTING OF "A" AND "B" AND NOW AN ADJUSTMENT OF SINE ADJ C WILL ROUND THE BOTTOM OF THE WAVEFORM PROPERLY.



SINE ADJ C MADE PROPERLY. OPTIMUM SINE WAVEFORM.

IT WILL PAY TO THINK OF THE "B" ADJUSTMENT AS ADDING SIGNAL TO THE SHAPING CIRCUIT; CCW ROTATION CAUSING FLATTENING, CW ROTATION CAUSING TRIANGULAR SHAPE. "A" ADJUSTMENT CONTROLS DC LEVEL AND RE-CENTERS THE WAVE. "C" ADJUSTMENT SERVES TO SHAPE ONLY THE BOTTOM OF THE WAVEFORM.

3-53 FINAL ADJUSTMENT

Connect the SINE output of the Type 250 to a distortion analyzer or waveform analyzer. If you use a waveform analyzer the first 10 harmonics should be checked with adjustments made considering the first five.

Carefully adjust SINE SHAPE A, B & C for minimum harmonic distortion. You should be able to reduce the total to a maximum of 1%. Changing V7 and repeating calibration step 3-51 should be tried if you cannot make specifications.

TYPE 250
Change VARIABLE to 1

Check the distortion at this end of the dial for no more than 2%.

TYPE 250
Change VARIABLE to 10
Change RANGE to 1000

Check distortion at 10kc for no more than 2%.

TYPE 250
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
OUTPUT ATTEN -- FULL CW

TEST SCOPE
TRIGGERING -- EXT FROM TRIGGER OUT
SWEEP TIME -- 1MSEC/CM
VERTICAL SENS -- APPROX 10V/CM
INPUT COUPLING -- DC

3-54 SINE DC LEVEL

SET THE TEST SCOPE TRACE FOR CENTER GRATICULE DC 0 VOLTS (GROUND). CONNECT THE TEST SCOPE TO THE SINE OUTPUT OF THE TYPE 250 AND ADJUST SINE DC LEVEL (R182) UNTIL WAVEFORM IS EXACTLY CENTERED ON SCOPE CRT.

******TYPE 251 ONLY CHECK COSINE ADJ., SEC. 3-84**********

3-6 RAMP CALIBRATION

TYPE 250
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
OUTPUT ATTEN -- FULL CW

TEST SCOPE
TRIGGERING -- EXT FROM TRIGGER OUT
SWEEP TIME -- 1MSEC/CM
VERTICAL SENS -- APPROX 10V/CM
INPUT COUPLING -- DC

WITH THE TEST SCOPE ON THE RAMP OUTPUT, ROUGH ADJUST RAMP LENGTH (R211) AND RAMP DC LEVEL (R223) FOR A STABLE PATTERN DC BALANCED AROUND GROUND. FINE ADJUST RAMP LENGTH (R211) FOR THE SAME AMPLITUDE OUTPUT AS THE OTHER THREE WAVEFORMS.

FINE ADJUST RAMP DC LEVEL (R223) FOR CENTER DC GROUND.

THERE SHOULD BE A "HOLD-OFF" TIME OF ABOUT 10% AT THE END OF EACH RAMP. THIS IS NORMAL AND IT IS THERE TO ALLOW THE RAMP TO FALL AND RE-ESTABLISH DC LEVEL BEFORE RISING AGAIN, AND TO ASSURE POSITIVE SYNC TO THE SQUARE WAVE GENERATOR.

3-6

TYPE 250

Change RANGE to 1000

TEST SCOPE

Change SWEEP TIME to 100usec/cm

Adjust timing capacitor (C115A) for 10 cycles in 10cm. (Note start of ramp and readjust if not linear.)

TYPE 250

Change VARIABLE to X1

TEST SCOPE

Change SWEEP TIME to 1msec/cm

Observe ramp amplitude and "hold-off" time (should be no more than 20% of total period).

TYPE 250

Change VARIABLE to 10
Change RANGE to 10
Change TRIGGER SOURCE to EXT

TEST SCOPE

Change SWEEP TIME to 10msec/cm

Press MANUAL trigger and check proper operation.

3-7 MAIN OUTPUT

TYPE 250

TRIGGER SOURCE -- INTERNAL
RANGE -- 100
VARIABLE -- 10
MAIN OUTPUT -- SQUARE
OURPUT ATTEN -- full CW
$\pm$DC LEVEL -- switched CCW to 0

TEST SCOPE
VERTICAL SENS -- 10V/CM
INPUT COUPLING -- DC
TIMING -- 1MSEC/CM
TRIGGER -- EXT FROM TRIGGER OUT

3-71 OUTPUT ATTEN.

WITH THE TEST SCOPE ON MAIN OUTPUT, CHECK FOR APPROX. 30 VOLT PEAK TO PEAK SIGNAL (MIN. OF 27 VOLTS). ROTATE THE ATTEN. KNOB FULL CCW. AMPLITUDE SHOULD DECREASE TO APPROX. 5 VOLTS (MUST GO BELOW 10V).

TEST SCOPE
CHANGE VERTICAL SENS TO 20V/CM

3-72 ±DC LEVEL

TURN ATTEN ON TYPE 250 BACK FULL CW AND CENTER TRACE ON SCOPE SCREEN. TURN ±DC LEVEL ADJUSTMENT CW OUT OF SWITCHED POSITION AND CHECK RANGE OF ADJUSTMENT FOR FULL BELOW GROUND THROUGH ABOVE GROUND OPERATION.

3-8 COSINE

TYPE 251
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
CYCLES/SEC -- 10
OUTPUT ATTEN -- FULL CW

TEST SCOPE
TRIGGERING -- EXT FROM TRIGGER OUT
SWEEP TIME -- 200 TO 500µSEC/CM
VERTICAL SENS -- APPROX 10V/CM
INPUT COUPLING -- DC

3-81 COSINE BALANCING

WITH THE SCOPE MONITORING THE COSINE OUTPUT JACK, ADJUST COSINE X10 BAL (R182) FOR A NON-DISTORTED WAVEFORM BALANCED BETWEEN + AND - CLIPPING LEVELS.

TYPE 251
CHANGE CYCLES/SEC TO 1

TEST SCOPE
Change SWEEP TIME 10X slower

Adjust COSINE X1 BAL (R237) for a non-distorted waveform between + and - clipping levels. Check through range of CYCLES/SEC dial for a balanced COSINE.

TYPE 251
Change RANGE to 1000
Change CYCLES/SEC to 10

TEST SCOPE
Change SWEEP TIME to 100X faster

Adjust COSINE COMP (R243) for a non-distorted waveform balanced between + and - clipping levels.

3-82 COSINE AMPLITUDE

Check amplitude of COSINE at 100 cycles, 1000 cycles and 10KC. Adjust COS AMPL (C125A) at 10KC to match lower frequencies.

TYPE 251
TRIGGER SOURCE -- INTERNAL
RANGE -- 100
CYCLES/SEC -- 10
OUTPUT ATTEN -- full CW

TEST SCOPE
TRIGGERING -- EXT from TRIGGER OUT
SWEEP TIME -- 200 to 500 μsec/cm
VERTICAL SENS -- approx 10V/cm
INPUT coupling -- DC

3-83 COSINE LEVEL

With scope monitoring the COSINE output jack, adjust the COSINE DC LEVEL (R241) until the COSINE has the same DC level as the SQUARE and TRIANGLE.

3-84 SINE DC LEVEL

With the scope monitoring the SINE output jack, adjust the SINE DC BAL (R245) until the SINE has the same DC level as the other waveforms.

ABBREVIATIONS USED IN OUR PARTS LIST

Cer.	CERAMIC	μμ	MICROMICRO
Comp.	COMPOSITION	M	MILLI
EMC	ELECTROLYTIC, METAL CASED	Prec.	PRECISION
EMT	ELECTROLYTIC, METAL TUBULAR	PT	PAPER TUBULAR
F	FARAD	Tub.	TUBULAR
H	HENRY	V	WORKING VOLTS DC
K	THOUSANDS OF OHMS	Var.	VARIABLE
MEG	MEGOHMS	W	WATT
μ	MICRO	WW	WIRE WOUND

THE COLUMN PRECEDING THE PARTS NUMBERS CONTAINS THE ABBREVIATIONS OF THE MANUFACTURERS FROM WHOM WE PURCHASE THE SPECIFIED PART. THESE ABBREVIATIONS ARE LISTED BELOW.

AB	ALLEN BRADLEY
AMX	AMPEREX
BB	BIRNBACK
CD	CONTINENTAL DEVICE CORPORATION
CL	CLAROSTAT
CRI	CENTRALAB
CTC	CHICAGO TELEPHONE COMPANY
CTS	CTS CORPORATION
DUB	CORNELL DUBILIER
ER	ERIE ELECTRONICS DIV.
EX	EXACT ELECTRONICS INC.
GE	GENERAL ELECTRIC COMPANY
GR	GRAYHILL
HL	ASTRON CORPORATION
IRC	INTERNATIONAL RESISTANCE CORP.
OAK	OAK ELECTRONICS CORPORATION
OHM	OHMITE
PEN	PENN RESISTOR CORPORATION
RCA	RADIO CORPORATION OF AMERICA
RMC	RADIO MATERIALS COMPANY
ST	SARKES TARZIAN INC.
TI	TEXAS INSTRUMENTS
TS	TUNG-SOL
WH	WESTINGHOUSE ELECTRIC

250 POWER SUPPLY

BULBS

B1	#47	6.3V				GE	150001

CAPACITORS

C1	80ufd		500V	EMC		SPR	290028
C2A&B	20/20ufd		450V	EMC		HL	290009
C3	80ufd		500V	EMC		SPR	290028
C4 A&B	20/20ufd		450V	EMC		HL	290009
C5 A&B	20/20ufd		450V	EMC		HL	290009
C6	.01ufd		200V		10%	AMX	285203
C7	.01ufd		200V		10%	AMX	285203
C8	.01ufd		200V		10%	AMX	285203
C9	2000ufd		20V	EMC		SPR	290029

DIODES

D1-D16	F4		400V			ST	152011
D17	VR10		10V	1W	10%	ST	152014
D18	CD1541		400V			CD	152010

RESISTORS

R1	120K	½W	Fixed	Comp	10%	AB	302124
R2	1M	½W	Fixed	Comp	10%	AB	302105
R3	100K	½W	Fixed	Comp	10%	AB	302104
R4	1.5M	½W	Fixed	Comp	10%	AB	302155
R5	10Ω	1W	Fixed	Comp	10%	AB	304100
R6	39K	½W	Fixed	Comp	10%	AB	302393
R7	680K	½W	Fixed	Comp	10%	AB	302684
R8	100K	½W	Fixed	Comp	10%	AB	302104
R9	1.5M	½W	Fixed	Comp	10%	AB	302155
R10	10	½W	Fixed	Comp	10%	AB	302100
R11	10	½W	Fixed	Comp	10%	AB	302100
R12	390K	½W	Fixed	Comp	10%	AB	302394
R13	47K	½W	Fixed	Comp	10%	AB	302473
R14	330K	½W	Fixed	Comp	10%	AB	302334
R15	1.5M	½W	Fixed	Comp	10%	AB	302155
R16	68K	1W	Fixed	Comp	10%	AB	304683
R17	200K	½W	Fixed	Prec	1%	PEN	309051
R18	165K	½W	Fixed	Prec	1%	PEN	309050
R19	100K	½W	Fixed	Prec	1%	PEN	309045
R20	210K	½W	Fixed	Prec	1%	PEN	309126
R21	150K	½W	Fixed	Prec	1%	PEN	309049
R22	100K	½W	Fixed	Prec	1%	PEN	309045
R23	15K ~~10K~~	~~2W 5W~~	Var	WW	-210V adjust	WL	~~311015~~ 311013
R24							
R25							
R26	270	2W	Fixed	Comp	10%	AB	306270
R27	25	5W	Fixed	WW	10%	OHM	308026

250 POWER SUPPLY

SWITCHES

SW1	Power Switch, SPST Toggle	BB	260134

TRANSISTORS

Q1	2N250	-11V Series regulator	TI	152001

VACUUM TUBES

V101	5651	Voltage reference	TS	154052
V102	6AU6	-210V DC amplifier	WH	154022
V103A	½-6080	+95V series regulator	TS	154056
V103B	½-6080	-210V series regulator	TS	154056
V104	6AU6	+95V DC amplifier	WH	154022
V105	12B4	+250V series regulator	TS	154045
V106	6AU6	+250V DC amplifier	WH	154022

250 MAIN GENERATOR

BULBS

B101	NE-2	200MA	60V	NEON		GE	150010

CAPACITORS

C100	4.7UUFD	500V	TUB	CER	10%	ER	281501
C101							
C102A	~~7-45~~ UUFD		VAR	CER		ER	~~281012~~
C102B	82UUFD	500V	TUB	CER	10%	ER	281528
C102C	.001UFD)						
C102D	.01UFD)		MATCHED TIMING CAPACITORS			EX	285213
C102E	.1UFD)		*****TYPE 251 ONLY*******				
C102F	1UFD)						
C103	.001UFD	500V	DISCAP			RMC	283000
C104	22UUFD	500V	TUB	CER	10%	ER	281511
C105	.001UFD	500V	DISCAP			RMC	283000
C106	22UUFD	500V	TUB	CER	10%	ER	281511
C107	47UUFD	500V	TUB	CER	10%	ER	281519
C108	47UUFD	500V	TUB	CER	10%	ER	281519
C109	22UUFD	500V	TUB	CER	10%	ER	281511
C110	22UUFD	500V	TUB	CER	10%	ER	281511
C111	.01UFD	250V	DISCAP			RMC	283005
C112	22UUFD	500V	TUB	CER	10%	ER	281511
C113	12UUFD	500V	TUB	CER	10%	ER	281505
C114	.001UFD	500V	DISCAP			RMC	283000
C115A	7-45UUFD		VAR	CER		ER	281012
C115B	82UUFD	500V	TUB	CER	10%	ER	281528
C115C	.001UFD						
C115D	.01UFD		MATCHED TIMING CAPACITORS			EX	285213
C115E	.1UFD		*****TYPE 251 ONLY*******				
C115F	1UFD						
C116	.001UFD	500V	DISCAP			RMC	283000
C117	22UUFD	500V	TUB	CER	10%	ER	281511
C118	.01UFD	250V	DISCAP			RMC	283005
C119	7-45UUFD		VAR	CER		ER	281012
C120	22UUFD	500V	TUB	CER	10%	ER	281511
C121	.01 UFD	250V	DISCAP			RMC	283005
C122	.01 UFD	250V	DISCAP			RMC	283005
C123	12UUFD	500V	TUB	CER	10%	ER	281505
C124	.01UFD	250V	DISCAP			RMC	283005
C125							
C126	.01UFD	250V	DISCAP			RMC	283005

DIODES

D101	T155		TI	152009
D102-109	~~CD1541~~ CD1541	400V	~~CD~~	~~152010~~ 152010

250 MAIN GENERATOR

RESISTORS

R100	27K	1W	FIXED	~~PREC~~ METAL FILM	~~1%~~ 5%	PEN	~~309107~~ 310140
R101	500K	½W	FIXED	PREC	1%	PEN	309140
R102	150K	½W	FIXED	PREC	1%	PEN	309049
R103	100K	½W	FIXED	COMP	10%	AB	302104
R104							
R105	15K	2W	VAR	WW	TIMING	CL	311012
R106							
R107	47K	½W	FIXED	COMP	10%	AB	302473
R108	220K	½W	FIXED	COMP	10%	AB	302224
R109	~~10K~~ 5.6K	1W	FIXED	PREC	1%	PEN	~~309100~~
R110	100	½W	FIXED	COMP	10%	AB	302101
R111	470K	½W	FIXED	COMP	10%	AB	302474
R119	47K	2W	FIXED	COMP	10%	AB	306473
R120	100	½W	FIXED	COMP	10%	AB	302101
R121	15K	5W	FIXED	WW		WL	308108
R122	5K	2W	VAR	WW SQ. W. SYMMETRY (X10)		CL	311012
R123	~~3.3K~~	~~2W~~	~~FIXED~~	~~COMP~~	~~10%~~	~~AB~~	~~306332~~
R124A & B	20K/30K	2W	VAR	WW MULTIPLIER (VAR)		CTS	311309
R125	1.8K	½W	FIXED	PREC	1%	PEN	309001
R126	100K	½W	FIXED	COMP	10%	AB	302104
R127	~~27K~~	~~½W~~	~~FIXED~~	~~COMP~~	~~10%~~	~~AB~~	~~302273~~
R128	50K	1W	VAR	COMP SQ. W. AMPLITUDE		CRI	311078
R129	82K	1W	FIXED	COMP	10%	AB	304823
R130	~~1.5K~~ 2.7K	½W	FIXED	COMP	10%	AB	~~302152~~
R131	~~220K~~ 210K	½W	FIXED	~~COMP~~ PREC	~~10%~~ 1%	AB	~~302224~~
R132	~~600K~~ 6M	½W	FIXED	PREC	1%	PEN	~~309142~~
R133	~~6M~~	~~½W~~	~~FIXED~~	~~PREC~~	~~1%~~	~~PEN~~	~~310720~~
R134	~~50M~~ 60M	½W	FIXED	PREC	1%	PEN	~~310730~~
R135	~~12M~~	~~½W~~	~~FIXED~~	~~PREC~~	~~1%~~	~~PEN~~	~~309267~~
R136	2M	1W	VAR	COMP HOLDOFF DC LEVEL		CRI	311076
R137	820	½W	FIXED	COMP	10%	AB	302821
R138	27K	2W	FIXED	COMP	10%	AB	306273
R139	56K	½W	FIXED	COMP	10%	AB	302563
R140	22M	½W	FIXED	COMP	10%	AB	302226
R141	180K	½W	FIXED	COMP	10%	AB	302184
R142	56K	½W	FIXED	COMP	10%	AB	302563
R143	10K	½W	FIXED	COMP	10%	AB	302103
R144	100K	½W	FIXED	COMP	10%	AB	302104
R145	100K	1/8 W	FIXED	PREC	1%	IRC	310714
R146	68K	1/8 W	FIXED	PREC	1%	IRC	310713
R147	100K	1/8 W	FIXED	PREC	1%	IRC	310714
R148	68K	1/8 W	FIXED	PREC	1%	IRC	310713
R149	8.2K	1W	FIXED	COMP	10%	AB	304822
R150	1.5M	½W	FIXED	COMP	10%	AB	302155
R151	50K	1W	VAR	COMP SQ. W. SYMMETRY (X1)		CTS	311023
R152	100K	½W	FIXED	PREC	1%	PEN	309045
R153							
R154	100	½W	FIXED	COMP	10%	AB	302101
R155	82K	2W	FIXED	COMP	10%	AB	306823
R156							
R157							
R158							
R159	150K	½W	FIXED	COMP	10%	AB	302154

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R160	100	½W	FIXED	COMP	10%		AB	302101
R161	100K	½W	FIXED	PREC	1%		PEN	309045
R162	100	½W	FIXED	COMP	10%		AB	302101
R163	100	½W	FIXED	COMP	10%		AB	302101
R164	100	½W	FIXED	COMP	10%		AB	302101
R165	200K	1W	FIXED	PREC	1%		PEN	310723
R166	15K	~~1W~~ 5W	VAR	~~COMP~~ WW	BOTTOM TRIANGLE		CTS	~~311303~~ 311013
R167	27K	½W	FIXED	PREC	1%		PEN	309107
R168								
R169								
R170	~~150K~~ 200K	½W	FIXED	PREC	5%		~~PEN~~ MET. FILM	SK 1.35 ~~309049~~
R171	50K	2W	VAR	COMP	A SINE SHAPE		AB	311023
R172	15K ~~10K~~	~~1W~~ 5W	VAR	~~COMP~~ WW	B SINE SHAPE		CTS	~~311015~~ 311012
R173	600K	½W	FIXED	PREC	1%		AB	309142
R174	~~150K~~ 200K	½W	FIXED	PREC	5%		~~PEN~~ MET. FILM	~~309049~~ 310135
R175	50K	2W	VAR	COMP	C SINE SHAPE		CTS	311077
R176	1K	½W	FIXED	COMP	10%		AB	302102
R177	1M	½W	FIXED	COMP	10%		AB	302105
R178	330K	½W	FIXED	PREC	1%		AB	309101
R179	150K	½W	FIXED	COMP	10%		AB	302154
R180	~~2.7M~~ 3.1M	½W	FIXED	COMP	10%		AB	~~302275~~
R181	~~8.2M~~ 10M	½W	FIXED	COMP	10%		AB	~~302825~~ 302106
R182	1.5M	1W	VAR	COMP			CTS	311042
R183	1.5M	½W	FIXED	COMP	10%		AB	302155
R184	120K	½W	FIXED	COMP	10%		AB	302124
R185	50K	1W	VAR	COMP	TRIANGLE DC LEVEL		CRI	311078
R186	82K	½W	FIXED	COMP	10%		AB	302823
R187	47K	2W	FIXED	COMP	10%		AB	306473
R188	47K	2W	FIXED	COMP	10%		AB	306473
R189								
R190	120K	½W	FIXED	COMP	10%		AB	302124
R191	100	½W	FIXED	COMP	10%		AB	302101
R192	3.9K	1W	FIXED	COMP	10%		AB	304392
R193	390K	½W	FIXED	COMP	10%		AB	302394
R194	470K	½W	FIXED	COMP	10%		AB	302474
R195	100	½W	FIXED	COMP	10%		AB	302101
R196	15K	2W	FIXED	COMP	10%		AB	306153
R197	680	½W	FIXED	COMP	10%		AB	302680
R198	100	½W	FIXED	COMP	10%		AB	302101
R199	27K	1W	FIXED	COMP	10%		AB	304273
*R200	100K	1W	FIXED	COMP	10%		AB	304104
R201	120K	½W	FIXED	COMP	10%		AB	302124
*R202	3K	1W	FIXED	COMP	10%		AB	303302
R203	1.2M	½W	FIXED	PREC	1%		PEN	309149
R204	12M	½W	FIXED	PREC	1%		PEN	309267
R205	~~20M~~	~~1W~~	~~FIXED~~	~~PREC~~	~~1%~~		~~PEN~~	~~310724~~
R206	~~50M~~ 60M	2W	FIXED	PREC	1%		PEN	~~310730~~ 310131
R207	~~50M~~ 60M	2W	FIXED	PREC	1%		PEN	~~310730~~ 310131
R208	15K	2W	FIXED	COMP	10%		AB	306153
R209	150K	½W	FIXED	COMP	10%		AB	302154
R210	150K	½W	FIXED	COMP	10%		AB	302154
R211	~~15K~~	~~1W~~ 5W	VAR	~~COMP~~ WW	RAMP LENGTH		CTS	~~311303~~ 311013
R212	10K	2W	FIXED	COMP	10%		AB	306103
R213	4.7K	½W	FIXED	COMP	10%		AB	302472
R214	50K	1W	VAR	(PART OF ±DC LEVEL SW105)			CTC	311025

*NOMINAL VALUE

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R215	27K	2W	Fixed	Comp	10%	AB	306273
R216	1K	1W	Fixed	Comp	10%	AB	304102
R217	100K	1W	Fixed	Comp	10%	AB	304104
R218	100K	2W	Var	Comp	Output Atten	AB	311026
R219	4.7K	½W	Fixed	Comp	10%	AB	302472
R220	47K	½W	Fixed	Comp	10%	AB	302473
R221	27K	2W	Fixed	Comp	10%	AB	306273
R222	47K	2W	Fixed	Comp	10%	AB	306473
R223	50K	.1W	Var	Comp	Ramp DC Level	CRI	311078
R224	180K	2W	Fixed	Comp	10%	AB	306184
R225	100	½W	Fixed	Comp	10%	AB	302101
R226	47K	½W	Fixed	Comp	10%	AB	302473
R227	3.3M	½W	Fixed	Comp	10%	AB	302335

SWITCHES

SW101	SPST Push Button	Manual Trigger	GR	260247
SW102	3 Wafer, 2 pos, rotary	Trigger Mode	OAK	260002
SW103	6 Wafer, 7 pos, rotary	Timing	OAK	260000
SW104	1 Wafer, 4 pos, rotary	Output Selector	OAK	260001
SW105	±DC Level (ganged with R214)		CTC	311025

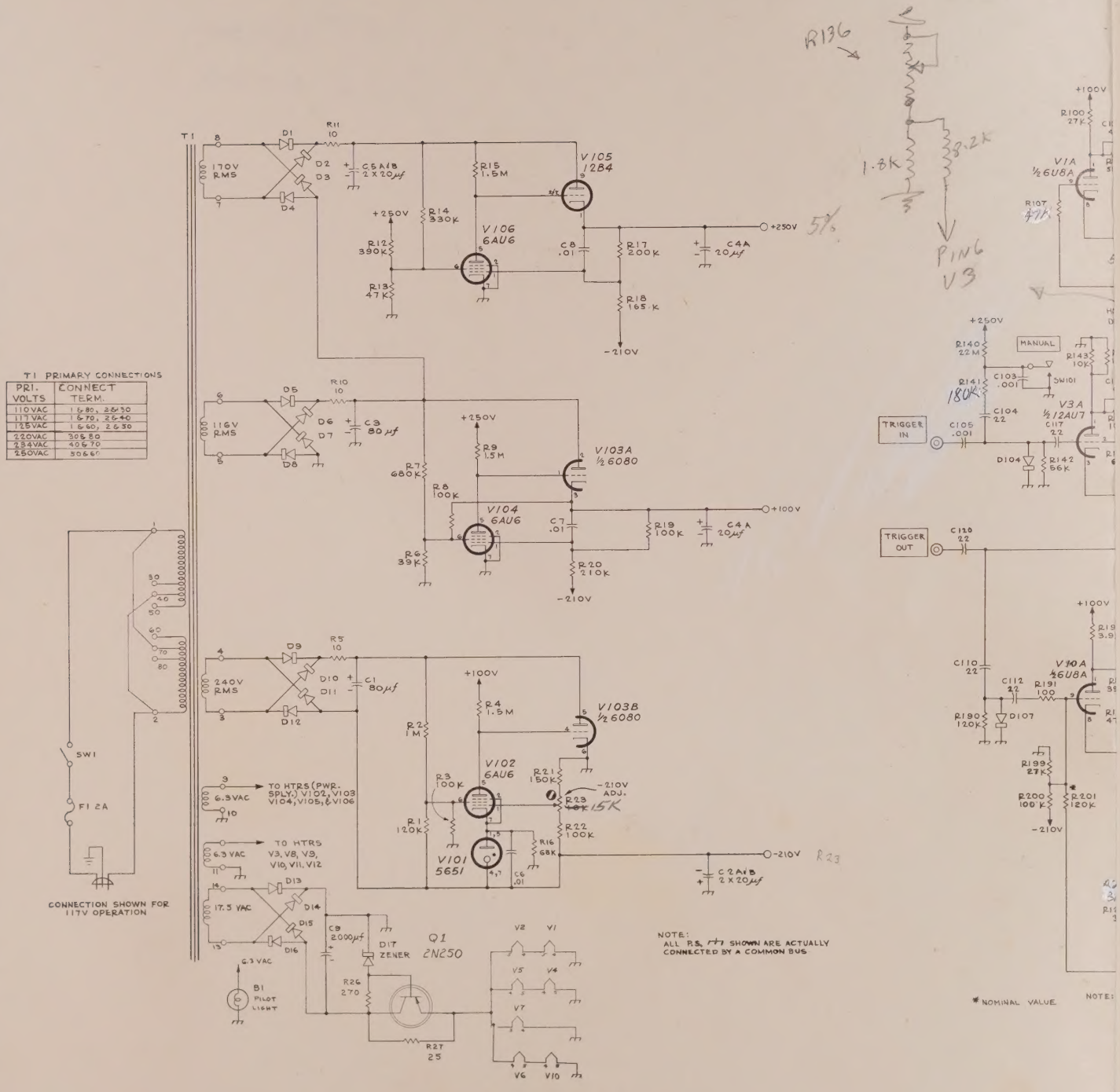
VACUUM TUBES

V1	6U8A	Square Wave Generator	RCA	154033
V2A	½6U8A	Miller Feedback CF	RCA	154033
V2B				
V3	12AU7	External Trigger Lockout Multi	AMX	154041
V4A	½6BL8	Miller Integrator	AMX	154057
V4B	½6BL8	Miller Integrator CF	AMX	154057
V5A	½6BL8	Miller Integrator	AMX	154057
V5B				
V6				
V7	12AU6	Sine Shaper Amplifier	WH	154044
V8A	½6DJ8	Sine Out CF	AMX	154187
V8B	½6DJ8	Ramp Miller CF	AMX	154187
V9	6AU6	Ramp Miller Integrator	WH	154022
V10	6U8A	Ramp Gate	RCA	154033
V11A	½6AW8A	Ramp Out CF	TS	154095
V11B	½6AW8A	Main Output CF	TS	154095
V12A	½6DJ8	Triangle Out CF	AMX	154187
V12B	½6DJ8	Square Out CF	AMX	154187

*** TYPE 251 ONLY ***

C125A	7-45μμFD		VAR	CER			ER	281012
C125B	47μμFD	500V	TUB	CER		10%	JR	281519
C125C	.001 μFD)	MATCHED TIMING CAPACITORS					EX	295214
C125D	1.0 μFD)							
R124A,B & C	20K/30K/30K	2W	VAR	WW	CYCLES/SECOND		CTS	311310
R182	100K	2W	VAR	COMP	COS X10 BAL		AB	311026
R189	270K	½W				10%	AB	302273
R229	SELECTED VALUE							
R230	150K	½W	FIXED	PREC		1%	PEN	309049
R231	120K	½W	FIXED	PREC		1%	PEN	309047
R232	1.2M	½W	FIXED	PREC		1%	PEN	309149
R233	12M	½W	FIXED	PREC		1%	PEN	309267
R234								
*R235	2.7K	1W	FIXED	COMP		10%	PEN	304222
*R236	150K	1W	FIXED	COMP		10%	AB	304104
R237	50K	¼W		VAR	COSINE X1 BAL		CTS	311077
R238	100K	½W	FIXED	PREC		1%	PEN	309045
R239	1M	½W				1%	PEN	309014
R240	2.5M	½W				1%	PEN	309025
R241	1.5M	1W	VAR	COMP	COSINE DC LEVEL		CTS	311042
R242	47K	1W	FIXED	COMP		10%	AB	304473
R243	2M	.1W	VAR	COMP	COSINE COMP		CRI	311076
R244	270K	½W				10%	AB	302273
R245	50K	.1W	VAR	COMP	SINE DC BAL		CRI	311078
R246	150K	½W				10%	AB	302154
R247	470K	½W				10%	AB	302473

*NOMINAL VALUE



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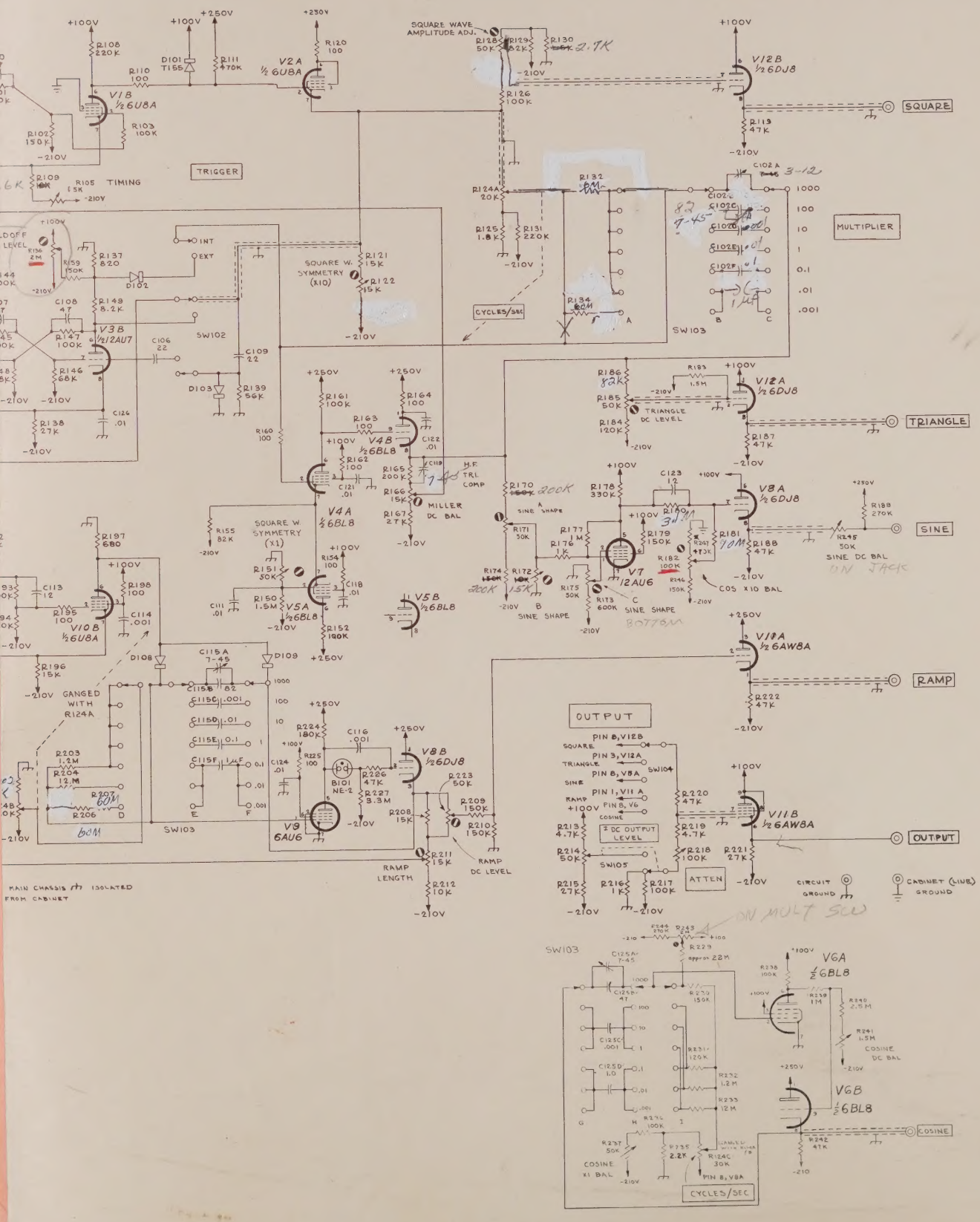
TYPE 251 FUNCTION GENERATOR


SQUARE WAVE AMPLITUDE ADJ.
V1B ½6U8A
V2A ½6U8A
V12B ½6DJ8
SQUARE
TRIGGER
R105 TIMING
INT
EXT
SQUARE W. SYMMETRY (X10)
CYCLES/SEC
MULTIPLIER
SW103
SW102
V3B ½12AU7
V12A ½6DJ8
TRIANGLE
TRIANGLE DC LEVEL
V4B ½6BL8
H.F. TRI. COMP
V4A ½6BL8
MILLER DC BAL
SQUARE W. SYMMETRY (X1)
V5A ½6BL8
V5B ½6BL8
V8A ½6DJ8
SINE
SINE DC BAL
SINE SHAPE
V7 12AU6
COS X10 BAL
V10B ½6U8A
V18A ½6AW8A
RAMP
GANGED WITH R124A
V8B ½6DJ8
V9 6AU6
RAMP LENGTH
RAMP DC LEVEL
OUTPUT
PIN 8, V12B
PIN 3, V12A
PIN 8, V8A
PIN 1, V11A
PIN 8, V6
2 DC OUTPUT LEVEL
SW104
SW105
ATTEN
V11B ½6AW8A
CIRCUIT GROUND
CABINET (LINE) GROUND
MAIN CHASSIS ⏚ ISOLATED FROM CABINET
V6A ½6BL8
V6B ½6BL8
COSINE
COSINE DC BAL
COSINE X1 BAL
CYCLES/SEC
PIN 8, V8A
ON MULT SCL